



Algorithm analysis

Final Report

A comparison of AdaBoost algorithms for time series forecast combination

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1. Introduction

Knowing how a certain product will be sold tomorrow or within a month helps companies manage their money and take strategies that allow them to make a profit. In many other cases, such the prediction of climate or the price of oil, it is also important to know what will happen in the future in order to take action and carry everything in a better way. In recent years it has been possible to predict all these variables thanks to time series forecasting, a method in which a set of data is analyzed in a given time and it is predicted what the new values will be for the future.

The use of machine learning to perform this process is something relatively new, but it has been very useful giving very accurate values to the real data, gaining more and more trust between companies and programmers that are dedicated to this.

That is why in this report an analysis will be made about the use of some variants of the Adaboosting algorithm for the prediction of time series, using different types of data in order to evaluate which of these algorithms is better when predict a set of data.





2. Description of the Algorithm

2.1 Explanation

The algorithm takes as input two parameters contained in the time series, then makes an initial prediction with a weak prediction model as a decision tree. This will give us a first classification of the data.

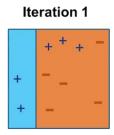


Figure 1. First Iteration of Adaboost.

Subsequently a greater weight is assigned to the data that had a bad prediction so that it can be well classified, while those that were misclassified will be given a lower weight.



Figure 2. Posterior iterations of the algorithm

Finally, all predictions are combined to obtain a much more precise model where the weights of each data have been taken into account.



Figure 3. Union of all weak predictions





2.2 Input

There are 4 input data:

X_train: matrix of 2 columns, where the first represents the month in which the sample was taken and the second represents the value that the company won in that month.

y_train: Represents the value that the company earns in a month (the same value as the second column of X train).

X_test: Data to test the algorithm (Same scheme as X_train).

y_test: Data to test the algorithm (Same scheme as y_train)

2.3 Output

Y_pred: Value that is obtained when predicting the values of X_train

2.4 Algorithm (Original Adaboost)

- 1) A for cycle starts from 1 to K (where K is the number of prediction models).
- 2) Input data (X_i, y_i) is entered.
- 3) A weight vector $w_i = 1$ is created.
- 4) A probability of be in training data set vector is created where:

$$p_{-}i^{k} = \frac{w_{i}^{k}}{\sum w_{i}^{k}}$$

5) A prediction model $f_k = x \to y$ is built, this will return the loss suffered L_i^k where $L_i^k \in \{0,1\}$ when predicting each observation through the calculus of the error between the observed value and the predicted value.

$$err = \left| \frac{f_k(x_i) - y_i}{y_i} \right|$$
 (AdaboostRT and original)

$$err = \left| \frac{f_k(x_i) - y_i}{D} \right|$$
 (AdaboostR2)

(If the error is bigger than a threshold, $L_i^k = 1$, else $L_i^k = 0$)

6) Calculate the average loss

$$L_i^- = \sum L_i^k p_i^k$$

7) The accuracy of the prediction is measured with a variable β_k , where β could be:





$$\beta_k = log \frac{1 - L_k}{L_k^-}$$
 (AbaboostR2 and Original)
$$\beta_k = log \frac{1}{L_k^-}$$
 (Adaboost.RT)

8) The weights of each observation i are updated for the next iteration k + 1

$$w_i^{k+1} = w_i^k \beta_k^{(1-L_i^k)}$$

9) Finally the predictions f_k (x_i) of the K models are combined (added) using their weights.

2.5 Algorithm Code

```
1.
              #Import libraries
2. import numpy as np
3. import pandas as pd
5. #Obtain data from the time series
6. dataset = pd.read_csv("C:/Users/Dell/Desktop/dx.csv")
7. X = dataset.iloc[:,[0,1]].values
8. y = dataset.iloc[:,1].values
10. #Save data in arrays
11. X_{\text{test}} = \text{np.zeros}((18,2))
12. X_{train} = np.zeros((len(X)-18, 2))
13. y_{test} = np.zeros(18)
14. y_{train} = np.zeros(len(X)-18)
15. for i in range(len(X_train)):
       X_{train[i][0]} = X[i][0]
17.
       X_{train[i][1]} = X[i][1]
18.
       y_{train}[i] = y[i]
19. for i in range(len(X_test)):
       X_{\text{test}[i][0]} = X[i+\text{len}(X_{\text{train}})][0]
20.
21.
       X_{\text{test}[i][1]} = X[i+\text{len}(X_{\text{train}})][1]
22.
       y_{test[i]} = y[i+len(X_{train})]
23.
24. #Normalize the data to obtain better results
25. from sklearn.preprocessing import StandardScaler
26. sc = StandardScaler()
27. X_train = sc.fit_transform(X_train)
28. X_test = sc.transform(X_test)
30. #Train the algorithm
31. from sklearn import tree
32. classifier = tree.DecisionTreeClassifier(criterion = 'entropy')
33. classifier.fit(X_train, y_train)
34. y_pred_inic = classifier.predict(X_test)
35. X_{train1} = np.zeros((len(X_{test}),2))
36.
37. for i in range(len(X test)):
38. X_{train1[i][1]} = X_{test[i][1]}
39. w = np.ones(len(X_test))
40. p = np.zeros(len(w))
41. LAvg = 0.6
42.
43. #Start the k cycles
44. while LAvg >= 0.5:
```





```
45.
46. #Update the vector of weights
47.
    for i in range(len(w)):
48.
      p[i] = (w[i]/np.sum(w))
49.
50. #Apply the weak prediction algorithm
    classifier = tree.DecisionTreeClassifier(criterion = 'entropy')
52.
    classifier.fit(X_train1, y_pred_inic, sample_weight=p)
53.
    y_pred = classifier.predict(X_test)
54.
55.
56.
    error_vec = np.zeros(len(y_test))
57.
    L = np.zeros(len(y_test))
58.
    thrhold = 0.04 \# Choose a value to compare the error
59.
60. #OBTAIN THE LOSS SUFFERED FOR Lk
61. ############### ADABOOST.RT AND ORIGINAL ####################
    for i in range(len(error_vec)):
      error_vec[i]=np.absolute(((y_pred[i]-y_test[i])/y_test[i]))
63.
64.
      if error_vec[i] > thrhold:
65.
        L[i] = 1
66.
      else:
67.
        L[i] = 0
68.
    LAvg = 0
72.
73.
   maxi = 0.00001
74.
    for i in range(len(error_vec)):
75.
     D = np.absolute((y\_pred[i] - y\_test[i]))
76.
      if D > maxi:
       maxi = D
77.
78.
79.
    for i in range(len(error vec)):
80.
      error_vec[i] = np.absolute((y_pred[i] - y_test[i]))/maxi
81.
82.
      if error vec[i] > thrhold:
83.
       L[i] = 1
84.
      else:
85.
       L[i] = 0
86.
88.
89.
90. #Obtain the Average of the values of the vector Lk
91.
    for i in range(len(L)):
92.
      LAvg = LAvg + (L[i]*p[i])
93.
94. #Obtain the predictive accuracy to calculate the new weights
    95.
96.
    b = np.log((1 - LAvg)/LAvg)
98.
99.
    100. \#b = np.log(1/LAvg)
103.#Calculate the weights fot the next iteration
104. for i in range(len(w)):
```





```
105. w[i] = (w[i] * pow(b, 1-L[i]))

106.

107.#Print the results

108.print("Y de testeo")

109.for i in range(len(y_test)):

110. print(y_test[i])

111.print("Y de prediccion")

112.for i in range(len(y_pred)):

113. print(y_pred[i])
```

*The algorithm was programmed in Python using "Spyder" in order to can use libraries like "numpy" and "pandas" to make easiest and fast the compiling and programming process.

2.5.1 System characteristics:

Memory (RAM): 16 GB

Processor: Intel Core i7

Operative System: Windows 10 Home



nnnn Observation of Training Data



3. Results

3.1 Input Values

		•									
2	Nonth	Company 1	Company 2	Company 3	Company 4	Company 5	???	Test Data to	be forecasted	l - now filled	with true va
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10											
11											
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15	13	6490	4790	12860	3280	2560	85		13070	2140	2930
15	14	5560	3330	11500	3780	3410	86		12480	2640	3630
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Figure 4. Input values.





3.2 Output Values:

Original Adaboost Algorithm

	51 training				51 training			121 training			126 training			126 training	SPECIAL
	Company 1	data		Company 2	data		Company 3	data		Company 4	data		Company 5	data	CASE
Month	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error
1	543	541	2	3470	3470	0	9350	9285	65	3380	3320	60	2450	2580	130
2	541	541	0	3350	3350	0	8300	8090	210	2280	2300	20	2950	2950	0
3	603	602	1	3740	3730	10	8090	8090	0	3260	3260	0	3350	3380	30
4	574	581	7	3370	3380	10	6670	6425	245	4700	4700	0	4450	4450	0
5	652	652	0	3320	3330	10	5205	5535	330	4760	4820	60	4210	4170	40
6	608	611	3	3750	3750	0	3645	3485	160	5480	5480	0	2650	2630	20
7	599	602	3	3210	3330	120	3595	3485	110	4620	4680	60	2414	2580	166
8	675	669	6	3870	3880	10	1014	1028	14	4240	4260	20	2823	2850	27
9	677	669	8	4270	4220	50	1139	1138	1	6160	7060	900	2444	2580	136
10	632	633	1	4200	4220	20	1045	1053	8	4120	4080	40	2666	2700	34
11	596	602	6	3790	3880	90	9520	9575	55	6900	7060	160	3052	3050	2
12	619	619	0	3920	3930	10	8940	9285	345	4020	4040	20	2397	2580	183
13	525	533	8	3480	3470	10	5885	5855	30	5400	5480	80	2463	2580	117
14	591	587	4	3160	3330	170	7690	7340	350	3560	3620	60	3385	3380	5
15	643	652	9	4070	4090	20	6245	5855	390	5460	5480	20	3290	3280	10
16	595	602	7	3420	3420	0	5560	5535	25	5580	5560	20	5408	5360	48
17	506	533	27	3810	3880	70	4850	5535	685	5220	5240	20	4000	4000	0
18	54	57	3	2950	2940	10	3830	3485	345	5200	5240	40	2513	2580	67
Average			5,27777778			33,8888889			187,111111			87,7777778			56,3888889

Figure 5. Output values, Original Adaboost.

Adaboost.RT Algorithm

		51 training			51 training			121 training			126 training			126 training	SPECIAL
	Company 1	data		Company 2	data		Company 3	data		Company 4	data		Company 5	data	CASE
Month	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error
1	543	541	2	3470	3470	0	9350	9285	65	3380	3360	20	2450	2580	130
2	541	541	0	3350	3350	0	8300	8600	300	2280	2300	20	2950	2930	20
3	603	602	1	3740	3730	10	8090	8090	0	3260	3260	0	3350	3380	30
4	574	581	7	3370	3380	10	6670	6425	245	4700	4700	0	4450	4450	0
5	652	652	0	3320	3330	10	5205	5285	80	4760	4820	60	4210	4320	110
6	608	602	6	3750	3750	0	3645	3485	160	5480	5480	0	2650	2700	50
7	599	602	3	3210	3150	60	3595	3485	110	4620	4680	60	2414	2580	166
8	675	669	6	3870	3880	10	1014	1028	14	4240	4200	40	2823	2850	27
9	677	669	8	4270	4220	50	1139	1136	3	6160	6240	80	2444	2580	136
10	632	633	1	4200	4220	20	1045	1053	8	4120	4080	40	2666	2700	34
11	596	602	6	3790	3780	10	9520	9575	55	6900	7060	160	3052	3050	2
12	619	633	14	3920	3940	20	8940	9000	60	4020	4040	20	2397	2580	183
13	525	533	8	3480	3470	10	5885	5900	15	5400	5480	80	2463	2580	117
14	591	602	11	3160	3150	10	7690	7340	350	3560	3620	60	3385	3380	5
15	643	652	9	4070	4090	20	6245	5900	345	5460	5480	20	3290	3280	10
16	595	602	7	3420	3420	0	5560	5540	20	5580	5480	100	5408	5360	48
17	506	533	27	3810	3780	30	4850	5285	435	5220	5240	20	4000	4000	0
18	54	57	3	2950	2940	10	3830	4050	220	5200	5240	40	2513	2580	67
Prom			6,61111111			15,555556			138,055556			45,555556			63,055555

Figure 6. Output values, Adaboost.RT.

Adaboost.R2 Algorithm

		51 training			51 training			121 training			126 training			126 training	SPECIAL
	Company 1	data		Company 2	data		Company 3	data		Company 4	data		Company 5	data	CASE
Month	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error	Test Value	Pred, Value	Error
1	543	533	10	3470	3470	0	9350	9285	65	3380	3320	60	2450	2450	0
2	541	533	8	3350	3350	0	8300	8740	440	2280	2300	20	2950	2920	30
3	603	611	8	3740	3730	10	8090	8090	0	3260	3260	0	3350	3350	0
4	574	581	7	3370	3380	10	6670	6650	20	4700	4700	0	4450	4450	0
5	652	611	41	3320	3330	10	5205	5535	330	4760	4820	60	4210	4320	110
6	608	611	3	3750	3750	0	3645	3485	160	5480	5480	0	2650	2630	20
7	599	602	3	3210	3330	120	3595	3485	110	4620	4680	60	2414	2450	36
8	675	669	6	3870	3880	10	1014	1028	14	4240	4200	40	2823	2850	27
9	677	669	8	4270	4220	50	1139	1138	1	6160	5480	680	2444	2450	6
10	632	611	21	4200	4160	40	1045	1053	8	4120	4100	20	2666	2700	34
11	596	602	6	3790	3780	10	9520	9575	55	6900	7060	160	3052	3050	2
12	619	611	8	3920	3930	10	8940	9000	60	4020	4040	20	2397	2350	47
13	525	533	8	3480	3470	10	5885	5855	30	5400	5480	80	2463	2450	13
14	591	581	10	3160	3330	170	7690	7340	350	3560	3620	60	3385	3380	5
15	643	611	32	4070	4090	20	6245	5855	390	5460	5480	20	3290	3220	70
16	595	589	6	3420	3420	0	5560	5535	25	5580	5480	100	5408	5360	48
17	506	509	3	3810	3780	30	4850	5535	685	5220	5280	60	4000	4000	0
18	54	57	3	2950	2940	10	3830	4050	220	5200	5120	80	2513	2450	63
Prom			10,6111111			28,3333333			164,611111			84,444444			28,3888889

Figure 7. Output values, Adaboost-R2.





3.3 Comparison

After performing the corresponding tests with the 5 different types of data in the 3 different types of algorithms, it was possible to determine that the Adaboosting.RT variant is the most efficient, since in most tests it had greater accuracy when predicting the data.

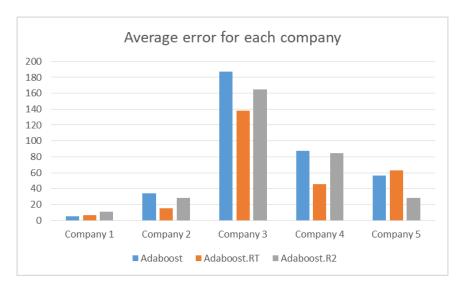


Figure 8. Comparison of errors.

Also It is possible to see that the original Adaboost algorithm have the biggest error of those three, so it can be concluded that when you change the parameters we could have better results for an specific case.





Conclusions

- In conclusion it was possible to see that the Adaboost.RT algorithm can give better forecasting among the 3 variants of Adaboosting, this can be observed also in the paper. This is because the predictive accuracy formula works better for this type of problems.
- Another observation is that the prediction model can give unexpected values, causing the
 algorithm to take longer without having to do with the type of algorithm that is being used,
 which is why the execution time was not taken into account as a measurement of the
 efficiency of the algorithms.

References

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